WATER QUALITY

Surface water and groundwater quality in the basin are generally good (Vandike 1995). The area covered by the basin is part of the Salem Plateau groundwater province, otherwise known as the Ozark aquifer. Streams draining from the Salem Plateau generally contain water that is calcium-magnesium-bicarbonate type with low sulfate and chloride levels (Vandike 1995). Sink holes and losing stream segments of the Ozark aquifer provide a direct conduit for surface water to enter groundwater. This allows for relatively quick groundwater recharge, and also provides a direct link for surface contamination to enter groundwater. This relatively quick recharge time is also responsible for great variations in the water quality of springs in the basin.

Water Use

There are over 85,000 people served in the basin by either public supplied surface water (9%), public supplied groundwater (39%), or private wells (52%) (Table 14). A greater proportion of people from the Lower Osage River HUC 10290111 below Bagnell Dam are served by public supplied surface water (19%) than are served by public supplied surface water in Lake of the Ozarks HUC 10290109 above Bagnell Dam (only 4%). A greater proportion of people (45%) above the dam are served by public supplied groundwater, whereas below the dam only 25% of the people are served by public supplied groundwater.

Throughout the basin, total water withdrawals equaled 11.32 million gallons per day (mgd). The majority of these withdrawals are from the HUC below Bagnell Dam (54% or 6.09 mgd). Above Bagnell Dam (HUC 10290109) has only 5.23 mgd or 46% of the total water withdrawals from the basin.

Total withdrawals from groundwater in the basin equaled 8.01 mgd whereas total withdrawals from surface water were only 7.61 mgd. There are more withdrawals from groundwater in the HUC above Lake of the Ozarks (56%) than below Bagnell Dam (45%). However there are more withdrawals from surface water (2.48 mgd) below the dam than in the HUC above Bagnell Dam (0.83 mgd). There are 10 public water supply districts in the basin (MDNR 1986).

Beneficial Use Attainment

he MDNR maintains a list of beneficial uses for classified waters of the basin. All classified waters have been assigned the beneficial uses of aquatic life protection, livestock and wildlife watering, and fish consumption by humans. In addition there are 298.5 miles of streams in the basin classified as supporting whole body contact. These streams are the Osage River (82 miles), Lake of the Ozarks (121 miles), Maries River (41.5 miles), Tavern Creek (37 miles), Grand Auglaize Creek (7 miles), and Wet Glaize Creek (10 miles)(MDNR 1986). Sections 303(d) and 305(b) of the Clean Water Act are a means for determining if beneficial uses are being attained.

Chemical Water Quality

Water quality of the basin is generally good. Ambient water quality data is monitored by the USGS at their gauging station on the Osage River near St. Thomas. For a detailed look at quarterly water quality constituents for the Osage River, see Table 15 for years 1984 and 1995. During those years, temperature ranged from 1.5 C to 27.5 C, pH ranged from 7.2-8, DO ranged from 3.9 to 12.8, fecal coliform ranged from <4 colonies/100ml in the spring of 1984 to 1,100 colonies/100ml in the spring of 1995, total nitrogen ranged from 0.12 mg/l to 0.8 mg/l (Missouri Water Quality Assessment Report 47, Volume III, 1997).

Water quality problems associated with increased urban and commercial development are an ongoing concern in the area surrounding Lake of the Ozarks. Increases in population density and recreational use are the primary reason for elevated nitrification and algal growth in Lake of the Ozarks.

The MDNR noted several water quality concerns for the basin (MDNR 1994). The first concern dealt with the continued commercial and residential development along the shoreline of Lake of the Ozarks. This development has increased the amount of treated sewage discharged to the lake. Many coves have excess algal growth from nutrients discharged into the lake by sewage. A second concern is groundwater contamination by improperly functioning septic tanks, leaking storage tanks and agricultural runoff or wastewater discharges to losing streams. Poorly constructed wells also greatly increase the chance for groundwater contamination. The problem is especially severe where the human population center sits atop geologic strata, such as the Lebanon area, which allow high rates of infiltration of surface water to groundwater. A third concern is the increasing number of CAFOs which have the potential, if not properly managed, to discharge harmful amounts of animal waste into spring branches and streams thereby degrading the water quality of those water bodies.

Pesticides have been detected in wells and springs throughout the Ozark aquifer, including the basin. Recent studies have detected a higher level of pesticide occurrences in springs than in wells. Most occurrences of pesticides in this groundwater province are probably directly related to the land use of the area surrounding the spring or well sampled.

Nitrates were found in only about 5% of the wells tested in the Salem Plateau groundwater province. Land use practices such as the application of fertilizer and human and animal waste can contribute high levels of nitrates to groundwater. Data collected between 1972 and 1990 found that less than 15% of samples from this groundwater province contained phosphorus at concentrations above detection levels. Springs and shallow wells were found to have higher phosphorus levels on average than deeper wells.

Sections 305(b) and 303(d) of the Clean Water Act

The MDNR reports on the status of water quality in surface waters according to section 305(b) of the Clean Water Act. MDNR summarizes the quality of Missouri waters every two years in these reports. Significant improvements in water quality have been made over the past quarter century in controlling pollution from municipal sanitary wastes, but major problems still exist from non-point source pollution.

Section 303(d) of the Clean Water Act requires states to list waters not expected to meet established state water quality standards even after application of conventional technology-based controls for which total maximum daily load (TMDL) studies have not yet been completed. The impaired waters list is produced every four years by the MDNR and includes waters for which existing required pollution controls are not stringent enough to maintain state water quality standards.

There are approximately 1.9 miles of 303(d) listed impaired streams and 50 acres of impaired reservoir found within the basin. Sources of biological impairment include damming, riparian degradation, channel alteration, urbanization, flow alteration, sedimentation, point source pollution, and non-point source pollution.

Fifty acres of the upper section of Lake of the Ozarks, downstream from Truman Dam, is included in the 303(d) list due to periodic gas supersaturation, occasional low DO levels and fish kills due to physical trauma (MDNR 1996, MDNR 2000). Truman Dam is listed as the source of the problem. The priority for development of TMDL is medium priority for this section of Lake of the Ozarks.

For the Lower Osage River, two separate 0.2 mile sections of river are listed due to loss of aquatic habitat resulting from sand and gravel dredging operations (MDNR 1996, MDNR 2000). TMDL development for this section of the river is listed as high priority.

Dry Auglaize Creek near Lebanon, Missouri is also listed as an impaired stream on the 303(d) list. A 1.5 mile section of this stream downstream from the Lebanon Waste Water Treatment Plant has been repeatedly polluted by sewage. Major concerns listed in this reach of stream include biological oxygen demand (BOD) and non-filterable residue (NFR). TMDL development for this section of Dry Auglaize Creek has not been completed.

For more information, contact MDNR's Water Pollution Control Program at 1-800-361-4827 or (573) 751-1300.

Point Source Pollution

Several waste water treatment facilities of the basin have historically violated their discharge permits. As human population increases, these problems are likely to increase. Water quality concerns associated with point sources are listed in the Missouri Water Quality Basin Plan (MDNR 1996). The problems associated with point source discharges at this time include an increase in continued commercial and residential development at Lake of the Ozarks, which increases untreated sewage discharged to the lake. Many coves have excessive algal growth due to the nutrients in sewage.

The Clean Water Act requires wastewater dischargers to have a permit establishing pollution limits, and specifying monitoring and reporting requirements. The National Pollutant Discharge Elimination System (NPDES) regulates household and industrial wastes that are collected in sewers and treated at municipal wastewater treatment plants. These permits also regulate municipal and industrial point sources that discharge into other wastewater collection systems or that discharge directly into receiving water.

The EPA also issues permits and maintains lists of toxic release, regulated hazardous waste, and permitted compliance system water dischargers into the basin. Current lists of permitees and supplemental information can be accessed at EPA's Surf Your Watershed website (EPA 2001).

Non-Point Source Pollution

Significant forms of non-point source pollution which enter streams of the basin include untreated sewage, fertilizer, animal manure, and atmospheric deposition.

While much of the highly developed areas along Highway 54 have been sewered and their waste waters treated and discharged to the Osage River downstream of LOZ, sewage from thousands of lakeside homes is discharged to LOZ. The effects of this has been studied and to date this discharge source has not been recognized as a significant source of pollution. Although coves with high numbers of households do often have increased algae blooms associated with increased nutrients, there has not been sufficient documentation to warrant poor water quality conditions as a result of this form of nutrient input on Lake of the Ozarks.

A portion of the fertilizer which is applied to fields and lawns returns to the atmosphere as ammonia gas, and most of the rest is either taken up by plants or converted to nitrate in the soil. Consequently, most of the dissolved nitrogen that enters streams from runoff of fertilizer occurs as nitrate. Nitrate is a very mobile form of nitrogen. It is not readily retained by the soil and is highly soluble in water. Because of this mobility, nitrate is often applied in greater quantities than crops or lawns require. Also, given its high solubility, nitrate may be washed into adjacent streams by rain, or it may leach into the groundwater system (Pucket 1994)

The basin has a sizeable number of livestock operations. If not properly handled and disposed of, the accumulated manure from these operations can add nutrients to streams. Where livestock roam freely, large amounts of nutrients in the form of manure are distributed over the landscape and represent a true non-point source of pollution. However, where animals are confined to feedlots, barns, or sheds, they become more of a point-source pollution problem. In these situations, large quantities of manure commonly are concentrated in one location, and the nutrients that leach to ground and surface waters from storage areas may pose a water-quality problem (Pucket 1994).

When livestock waste enters a stream, nutrient contents of the stream rise and fecal coliform counts increase. Increases in nitrogen can result in dense algal growth which can deplete dissolved oxygen in the stream. Fish become stressed under these conditions, and in some cases fish kills occur. Also, cattle which drink the contaminated water may experience reduced weight gains. Increases in fecal coliform counts also make streams unsafe for human recreation.

Atmospheric deposition of nutrients such as nitrogen originates primarily from the combustion of fossil fuels, such as gas, coal, and oil. Atmospheric deposition of these nutrients often occurs with precipitation such as rain, snow, hail, or fog. The largest sources of these pollutants are coal and oil-burning electric facilities and large industries. However, automobiles, trucks, buses, and other forms of transportation can account for more than one-third of these sources. Even though these nutrients often come from point sources such as industrial plants, they still are called non-point source pollutants when they reach water bodies through precipitation. In the past, this type of non-point source pollution was largely ignored because it did not fit the traditional definition of a non-point source. This form of non-point source pollution can be significant. Over half of the nitrogen emitted from fossil-fuel-burning plants, vehicles, and other sources are deposited in watersheds (Pucket 1994).

Sediment input from construction sites which do not use best management practices can have serious negative impacts on streams and impoundments. Sediment input from crop fields is not as much of a concern throughout the basin, but can have localized negative impacts. Land use in the basin is listed as approximately 54.8% forest, 39.7% grassland, 2.5% open water, 1.6% cropland, and 1.6% urban. Sheet and rill erosion in the basin is estimated by the NRCS to be 2.5 tons/acre/year. Gully erosion is considerably less with 0-0.16 tons/acre/year. Since the majority of the land cover in this basin is forest and grassland, streams of the basin generally do not receive large amounts of sediment, and agricultural erosion is not considered to be a basin- wide problem. However, urbanization is continually increasing throughout the basin. With urbanization comes the destruction of vegetative cover and construction parking lots, buildings, shopping centers and residences, all impervious surfaces. With the steep hillsides and tremendous runoff effects of rainfall in the basin, if construction sites do not use best management practices to control erosion during their operations, sediment is transported and deposited in streams and reservoirs of the basin.

Prior to the construction of Truman Dam, the Upper Osage River carried significant amounts of sediment, as well as nitrogen and phosphorus into the basin. With the construction of Truman Dam, however, the sediment and nutrient inputs from the Upper Osage River have decreased.

Water Quality Studies and Concerns

A series of limnological studies have been conducted to monitor the water quality of Lake of the Ozarks. Initially the studies were designed to evaluate the effect of Truman Dam on Lake of the Ozarks (Jones and Novak 1981, Jones and Kaiser 1988). Sampling was continued to monitor and evaluate any changes in water quality over time (Jones 1993, Kaiser and Jones 1999). Jones and Kaiser (1988) found decreased loading of total phosphorus and suspended solids, and increased levels of chlorophyll, suggesting that Lake of the Ozarks had increased in productivity. Indirect evidence suggested that conditions were more favorable for algal growth after the construction of Truman Dam because of increased water clarity in Lake of the Ozarks. The water which entered Lake of the Ozarks had lower amounts of dissolved solids since these were now settling out in Truman Reservoir.

Water quality concerns associated with increased urban development will need to be addressed in the future for Lake of the Ozarks and streams around Lebanon, Missouri. The lower part of Lake of the Ozarks receives substantial nutrient inputs associated with development. Point source discharges, septic tanks, and lawn maintenance are causing localized, high levels of suspended algae in some coves.

Bacterial contamination in coves of lower Lake of the Ozarks is a continuing concern. However, studies in the past have shown that all coves tested had low levels of fecal coliform bacteria well within state water quality standards for whole body contact recreation (MDNR 1996).

Mitzelfelt (1985) studied Lake of the Ozarks to determine if urbanization and development was affecting water quality. Small but consistent differences in trophic state of near shore waters were found as development of the adjacent shoreline increased. Data based on nutrient levels, chlorophyll a levels, and secchi disk readings categorized the lower Lake of the Ozarks as mesotrophic although chlorophyll a and secchi readings bordered on eutrophic. Fecal coliform data showed large increases with increased development particularly over summer weekends and holidays. Many of the samples exceeded standards for whole body contact recreation. The high levels of fecal coliform bacteria were attributed to inadequate septic systems and occasional pleasure boat discharges of untreated sewage. Mitzelfelt (1985) also suggested it was unlikely that urbanization and development would have a major impact on Lake of the

Ozarks water quality because of dilution and flushing effects of the reservoir.

The Missouri Department of Health (MDOH) and MDNR continue to monitor the water quality of Lake of the Ozarks to ensure that adequate wastewater and stormwater management are undertaken. Study results indicate that there is an increase in fecal coliform counts after heavy rainfall, suggesting the waste load is a result of runoff. Acknowledging this fact, state water quality regulations stipulate that the standard for fecal coliform bacteria does not apply during periods of stormwater runoff (10 CSR20-7.031(4)(c)).

Mitzelfelt (1985) also found that Lake of the Ozarks becomes temperature stratified during the summer months. The cold, lower layer of water, termed the hypolimnion, has very little or no dissolved oxygen (DO). Each summer, leakage and release of this hypolimnetic water through the turbines causes many miles of the Osage River downstream from the Bagnell Dam to have unnaturally low DO. Many fish kills have occurred in dam's tailwater as a result.

AmerenUE and MDC jointly developed and agreed upon operational changes to increase tailwater DO and reduce the likelihood of fish kills due to low DO. To increase DO of hydropower generation releases, AmerenUE allows more air to mix with the water by opening vents on all main turbines when DO is less than 3 mg/l at the turbine intakes. From June 1 to July 14, the DO of minimum releases (455 cfs; 25% gate setting) is improved by operating the house turbines with vents open. From July 15 to September 30, the house turbines are operated at 16% gate setting with vents open, which increases DO but reduces the flow to 385 cfs. In addition, when DO about 2,000 feet downstream near the MDC boat ramp is less than 2.5 mg/l, one main turbine is operated for one hour on and one hour off from 8:00 P.M. to 8:00 A.M. each night. Since implementation of the operating agreement in 1996, no fish kills have been reported due to low DO problems below Bagnell Dam.

Even with the operating agreement, summer DO levels still remain below the MDNR standard of 5 mg/l for many miles downstream of Bagnell Dam. During minimum flow conditions (385-455 cfs), DO can be 1 mg/l in some locations near the dam and can remain below 5 mg/l for up to 10 miles downstream. DO can remain below 5 mg/l for up to 70 miles downstream during peak generation. Although fish kills have been prevented since implementation of the 1996 agreement, DO levels below the 5 mg/l standard can stress fish, mussels, and aquatic insects, likely reducing growth, spawning, distribution, and diversity of aquatic biota.

The effects of gravel mining (the removal of gravel from streambeds) can be disastrous to a stream and the surrounding stream corridor as well as upstream and downstream stream reaches. Water quality problems associated with gravel mining in the basin include: increased turbidity downstream from mining, increase in gradient, increased water temperatures due to a disruption in the stream flow, and increased sedimentation. Little information on the extent of past or present gravel mining is known for the basin.

In recent years, there has been a relaxing of the rules and case laws concerning instream gravel mining operations in the United States. From 1995-1998, the USACE regulated instream removal of gravel from streams in the basin. Currently, there are no permits required for non-commercial gravel mining operations. Permits are required for commercial gravel mining operations. These are handled through the MDNR's Land Reclamation Division.

In the past, large commercial gravel operations have caused major upstream and downstream erosion within the basin. Linn Creek is one such example. A commercial gravel mining operation adjacent to the town of Linn Creek, Missouri mined considerable quantities of gravel from the adjacent streambed causing a 5-10 foot deep headcut to move upstream (Greg Stoner, MDC, personal communication). The effects of this operation were documented upstream for miles on Linn Creek and into two tributaries. A grade control structure built to protect one bridge later failed due to further incision. Other infrastructure damage along Linn Creek required $20,000 worth of repairs for telephone poles, cables, and phone lines and $19,000 worth of repairs for a sewer line. Up to 100 ft of lateral bank erosion occurring over a nine year period undermined nine residences and two businesses, resulting in an $875,000 buyout of those properties in 1994 by the Federal Emergency Management Agency. Numerous structures are still in jeopardy. It is estimated that the damages caused by this gravel mining operation alone may exceed $1 million dollars before the streambed re-stabilizes. Sellar's Creek and Tavern Creek are two more examples where gravel removal has severely damaged habitat, water quality, and caused fish kills.

The majority of the gravel removal operations are non-commercial and presently not regulated. These mining operations are typically operated by landowners or local road districts to remove gravel from streams for use on farm roads. Landowners also rearrange gravel bars in an attempt to alleviate stream bank erosion. The cumulative effects of this small-scale but widespread gravel removal and streambed alteration are unknown at this time.

Although the cumulative effects of non-commercial gravel removal have not been well documented, they are considered to be a significant concern and possible source of habitat and water quality degradation. Between 1993-1998, the USACE regulated all instream gravel mining operations including non-commercial operations. The extent that gravel mining was permitted both commercially and non-commercially in the basin was extensive and is shown in Figure 32. Since the USACE now has limited involvement regulating this activity, the extent that these operations are currently removing gravel in most cases may be going unmonitored and having severe local impacts on streambeds, streambanks, riparian vegetation, and the species that rely on them.

Volunteer Water Quality Monitoring and Stream Clean-up

Volunteer water quality monitoring in the basin is conducted by both the Missouri Stream Teams program and the Lakes of Missouri Volunteer Program. The Missouri Stream Teams program was initiated by MDC, MDNR, and the Conservation Federation of Missouri. The Lakes of Missouri Volunteer Program is coordinated by the University of Missouri-Columbia, School of Natural Resources and funded by the EPA through MDNR.

Missouri Stream Team sampling sites for the basin are depicted in Figure 18. These volunteers participate in various projects such as litter cleanup, macroinvertebrate sampling, tree planting for bank stabilization, stream inventories, and educational exhibits. For a complete listing of the Missouri Stream Teams and to obtain the data that they have collected, please see the official Missouri Stream Team website.

Fish Consumption Advisories

The MDOH issues fish consumption advisories for Missouri. MDC collects fish annually for use in consumption advisories. The most current consumption advisory information is available from the MDOH.

During 2001 the MDOH issued a statewide advisory regarding the consumption of largemouth bass in Missouri. The advisory targets pregnant women, nursing mothers, and children advising that they not consume largemouth bass. It also advises consumption of no more than a specified amount of bass by the remainder of the population. This advisory was issued due to a reduction in EPA's action level for mercury in fish tissue from 1,000 ppb to 200-300 ppb. Missouri's largemouth bass population has for many years had fish with mercury levels in the 200-300 ppb range. In 2001, 100% of the bass collected in Missouri and analyzed for metals contained mercury. Of those samples approximately 32% exceeded 200 ppb. The primary source of mercury to the environment is through air emissions. In Missouri, coal burning boilers account for 90% of mercury emissions.

Fish Kills

MDC maintains a listing of all reported fish kills within the basin and a list of pollution occurrences where no fish kill was reported but may have in fact been detrimental to aquatic populations. The earliest reported fish kill on record was in April of 1960 on a creek near Gravois Mills. Unfortunately, there is no record of the number killed or the cause of that fish kill. The most recent fish kill to date occurred in Lake of the Ozarks in October of 2001. An estimated 70 paddlefish were killed after becoming impinged on turbine intakes on the front of the dam.

The causes of recorded fish kills in the basin have included: low dissolved oxygen, sludge, petroleum, diesel fuel, sewage, gas bubble disease, temperature, parasites, physical injury from turbines, impingement on the face of Bagnell dam, detergent, hog manure, dairy cattle manure, molasses, severe siltation, stream habitat destruction, channelization, and herbicide. The estimated numbers of fish killed per incident range from as few as 3 fish killed in Lake of the Ozarks due to herbicide application to as many as 421,785 in Lake of the Ozarks due to a gas supersaturation in the water resulting from to the operation of Truman Dam.

Figure 18. Stream Team Water Quality Monitoring Sites for the East Osage River Basin

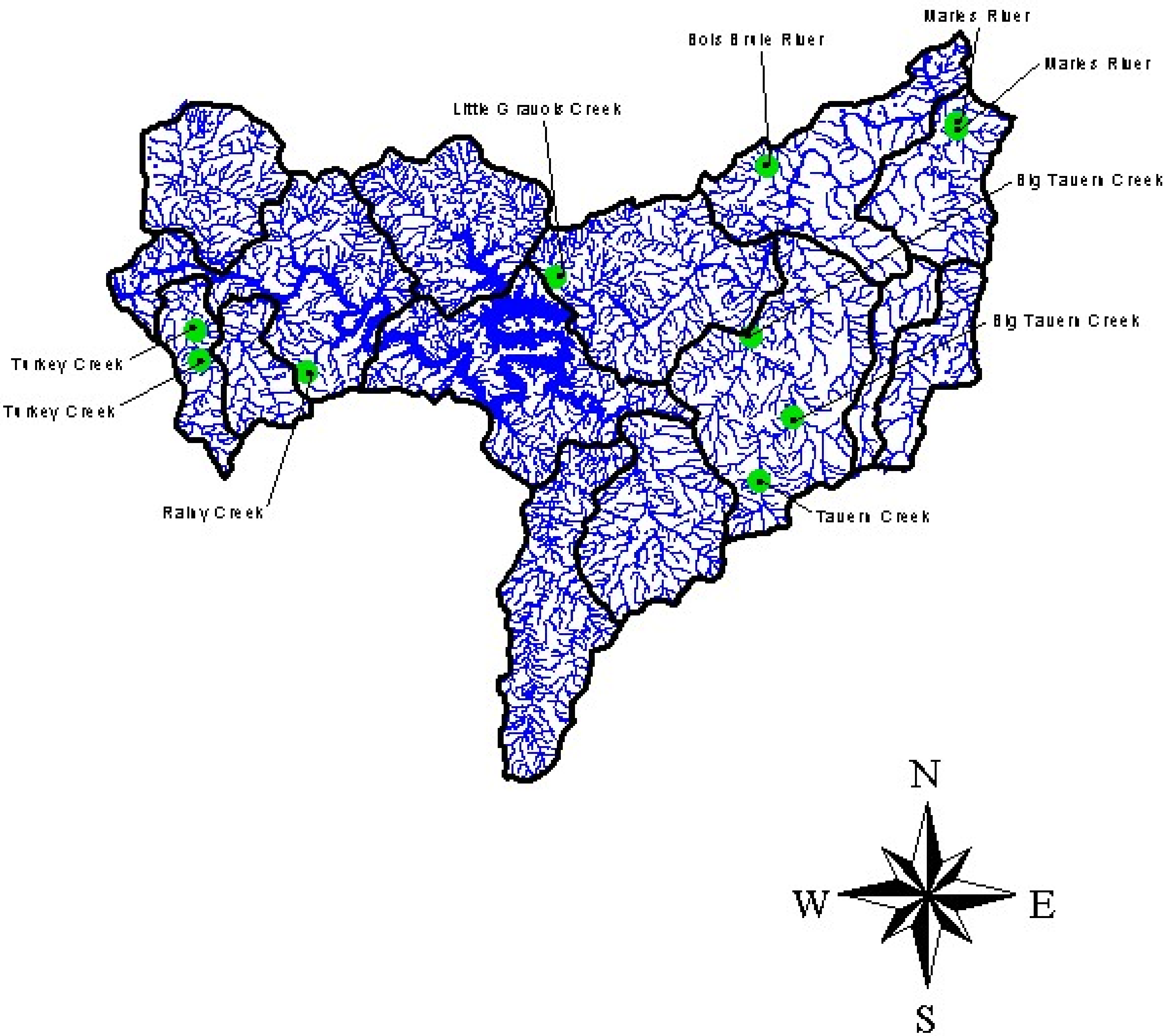

Table 14. Water use in the East Osage River Basin .

Category	10290109 Lake of the Ozarks	10290111 Lower Osage	Total
POPULATION SERVED			
Number of People Served by Public Supplied Surface Water	2,210 (4 %)	5,730 (19 %)	7,940 (9 %)
Number of People Served by Public Supplied Groundwater	25,350 (45%)	7,630 (25%)	32,980 (39%)
Total Number of People Served by Public Water Supply	27,560	13,360	40,920
Total Number of People Served by Private Wells	28,500 (51%)	16,170 (56 %)	44,670 (52 %)
Total Number of People Served in Area	56,060 (65% of total)	29,530 (35 % of total)	85,590 (100 %)
GROUNDWATER WITHDRAWALS (Million Gallon/Day (mgd))			
Groundwater Withdrawals for Commercial Use	0.54	0.18	0.72
Groundwater Withdrawals for Livestock Use	0.28	0.27	0.55
Groundwater Withdrawals for Public Water Supply	1.72	2.04	3.76
Groundwater Withdrawals for Irrigation	0.04	0	0.04
Private Well Withdrawals	1.71	0.96	2.87
SURFACE WATER WITHDRAWALS (mgd)			

Private Surface-water Withdrawals	**0**	**0**	**0**
Surface Water Withdrawals for Public Water Supply	**0.15**	**1.53**	**1.68**
Surface Water Withdrawals for Livestock Use	**0.04**	**0.85**	**0.89**
Surface Water Withdrawals for Commercial Use	**0**	**0**	**0**
Surface Water Withdrawals for Irrigation	**0.07**	**0.05**	**0.12**
TOTAL WITHDRAWALS (mgd)			
Total Groundwater Withdrawals	**4.4**	**3.61**	**8.01**
Total Surface Water Withdrawals	**0.83**	**2.48**	**3.31**
Total Withdrawals for Public Water Supply	**1.87**	**3.57**	**4.44**
Total Withdrawals for Livestock Use	**0.91**	**1.12**	**2.03**
Total Withdrawals	**5.23 (46 % of total)**	**6.09 (54 % of total)**	**11.32 (100%)**

Table 15. Quarterly water quality data from the Osage River near St. Thomas, Missouri, 1984 and 1995. (Data source USGS, 1985, and 1996).

CONSTITUENT	FALL		WINTER		SPRING		SUMMER	
	1984	1995	1984	1995	1984	1995	1984	1995
Instanteneous discharge, (ft3/second)	**20,400**	**12,300**	**6,730**	**21,600**	**35,100**	**52,700**	**2,020**	**31,600**
Temperature, (Celcius)	**12.0**	**15.5**	**1.5**	**3**	**16.5**	**19**	**25**	**27.5**
Specific Conductance, (Fs/cm)	**28**	**272**	**251**	**254**	**255**	**281**	**283**	**248**
pH, whole water, field measurement	**8**	**7.7**	**7.8**	**7.2**	**7.9**	**7.7**	**7.6**	**7.5**
Oxygen, dissolved (mg/l)	**8.2**	**9**	**12.8**	**12.6**	**9.2**	**9.7**	**6**	**3.9**
Fecal coliform, (colonies/100 ml)	**96**	**1**	**10**	**13**	**<4**	**1,100**	**39**	**5**
Fecal streptococci, (colonies/100 ml)	**220**	**475**	**52**	**115**	**80**	**1,260**	**22**	**205**
Alkalinity, (mg/l as $CaCO_3$)	**106**	**102**	**106**	**83**	**91**	**105**	**123**	**90**
Bicarbonate, dissolved (mg/l)	**–**	**125**	**–**	**99**	**–**	**126**	**–**	**109**
Nitrate + Nitrite, total as N (mg/l)	**0.33**	**0.12**	**0.56**	**0.47**	**0.8**	**0.24**	**0.45**	**0.17**
Phosphorus, dissolved (mg/l)	**0.01**	**0.03**	**0.02**	**0.03**	**<0.02**	**0.09**	**0.02**	**0.02**

Calcium, dissolved (mg/l)	**39**	**0.4**	**37**	**33**	**33**	**34**	**40**	**34**
Magnesium, dissolved (mg/l)	**11**	**9.8**	**11**	**7.9**	**7.7**	**10**	**8.8**	**6.9**
Sodium, dissolved (mg/l)	**5.5**	**4.3**	**5.2**	**5.7**	**7.9**	**4.5**	**5.4**	**8.2**
Potassium, dissolved (mg/l)	**2.9**	**2.8**	**3.2**	**3.4**	**2.4**	**2.3**	**2.6**	**3.2**
Sulfate, dissolved (mg/l)	**26**	**18**	**27**	**22**	**29**	**20**	**26**	**17**
Chloride, dissolved (mg/l)	**5.2**	**8.9**	**6.3**	**8.4**	**5.1**	**5.4**	**4.9**	**3.7**
Flouride, dissolved (mg/l)	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**<0.1**	**0.2**	**0.1**
Total solids, dissolved (mg/l)	**159**	**155**	**170**	**216**	**159**	**158**	**153**	**142**
Aluminum, dissolved (Fg/l)	**<10**	**<10**	**30**	**–**	**20**	**80**	**20**	**–**
Iron, dissolved (Fg/l)	**14**	**6**	**21**	**13**	**18**	**93**	**9**	**<3**
Manganese, dissolved (Fg/l)	**8**	**6**	**8**	**69**	**6**	**7**	**22**	**6**
Nickel, dissolved (Fg/l)	**11**	**<1**	**4**	**<1**	**<1**	**<1**	**10**	**1**
Strontium, dissolved (Fg/l)	**120**	**97**	**110**	**89**	**110**	**83**	**130**	**120**

Table 16. Estimated riparian corridor conditions* for 11-digit, 9-digit, and combined hydrologic units of the East Osage River Basin. (Note: Lower Osage River HUC and Miller County River Hills HUC do not have data on the Osage River channel itself included in percentages.)

Hydrologic Unit Name	Hydrologic Unit Number	Riparian Forest	Riparian Grassland	Riparian Cropland	Riparian Urban
Lower Osage River	10290111060	54 %	40 %	5 %	< 1 %
Lower Maries River	10290111050	55 %	37 %	7 %	< 0.01 %
Upper Maries River	10290111040	52 %	47 %	< 1 %	< 1 %
Little Maries River	10290111030	45 %	54 %	< 1 %	0
Tavern Creek	10290111010	60 %	38 %	1 %	< 1 %
Wet Glaize Creek	10290109070	56 %	43 %	< 1 %	< 1 %
Dry Auglaize Creek	10290109060	42 %	56 %	1 %	1 %
Deer Creek	10290109030	64 %	35 %	< 0.1 %	0
Turkey Creek	10290109010	54 %	45 %	< 1 %	0
Cole Camp Creek	10290109020	54 %	40 %	5 %	< 0.01 %
Upper LOZ Hills	10290109040	75 %	24 %	< 1 %	< 1 %
Gravois Arm	10290109050	73 %	25 %	1 %	< 0.1 %
Lower LOZ Hills	10290109080	82%	17 %	< 1 %	< 1 %
Miller County Osage River Hills	10290111020	65 %	32 %	2 %	< 1 %
LOZ HUC	10290109	63 %	35 %	1 %	< 1 %
Lower Osage River HUC	10290111	58 %	38 %	3 %	< 0.1 %
All Above Subbasins Combined		61 %	36 %	2 %	< 1 %
Lower Osage River	10290111060	46 %	24 %	19%	< 1 %
Miller County Osage River Hills	10290111020	42 %	21 %	22 %	< 1 %

*** riparian corridor conditions estimated by summation of satellite image pixels adjacent to streams depicted on satellite images.**

Estimated riparian corridor is 90 meters wide (extends for 45 meters on either side of the center of each stream).

Table 19. Fish present in MDC fish community samples sampled by seining or visual observation in the East Osage River Basin by subbasin and most recent time period collected*

Common Name	Lower Osage R.	Lower Maries R.	Upper Maries R.	Little Maries R.	Tavern Cr.	Wet Glaize Cr.	Dry Auglaize Cr.	Deer Cr.	Turkey Cr.	Cole Camp Cr.	Upper LOZ Hills	Gravois Arm	Lower LOZ Hills	Miller Co Osg R Hills
Chestnut lamprey		B			C									C
Shovelnose sturgeon														C
Lake sturgeon														A
Longnose gar	B				D					D				C
Shortnose gar	B				D									C
American eel														C
Gizzard shad	D	D			D			C	D	A		A		D
Skipjack herring														C
Mooneye					B									
Goldeye	B													C
Largescale stoneroller	D	D	D	D	D	D	D	D	D	D	D	D		D

Central stoneroller	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
Red shiner	**B**	**D**	**A**	**A**	**D**	**D**	**D**			**A**		**A**		**C**
Common carp	**B**				**D**	**D**	**D**	**D**	**D**	**D**				**D**
Goldfish						**D**								**D**
Gravel chub	**B**				**D**									**C**
Bleeding shiner	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Redfin shiner	**A**	**D**	**A**	**A**	**D**		**D**		**D**	**D**				**C**
Wedgespot shiner		**D**	**A**	**D**	**D**	**D**								**C**
Hornyhead chub	**D**	**D**	**D**	**D**	**D**	**D**	**A**	**D**	**B**	**A**	**C**	**D**		**D**
Mimic shiner														**D**
Emerald shiner	**B**													**C**
Golden shiner					**C**	**D**	**D**			**D**		**D**		**D**
Ghost shiner		**A**												**D**
Blacknose shiner			**A**	**A**			**D**							
Sand shiner	**B**	**D**	**A**		**D**	**D**	**D**			**D**		**A**		**C**
Ozark minnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**

Western silvery minnow	**B**	**A**			**C**									
Rosyface shiner	**D**	**D**			**D**	**D**	**D**							**D**
Striped shiner														**D**
Suckermouth minnow	**B**	**C**			**C**					**A**				**A**
Southern redbelly dace	**D**		**D**	**D**	**D**	**D**	**D**	**D**			**D**	**D**		**D**
Bluntnose minnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**		**D**
Fathead minnow			**D**			**D**	**C**			**D**		**A**		**D**
Gravel chub	**B**	**C**			**D**									**C**
Creek chub	**D**	**C**	**D**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Speckled chub														**C**
White sucker					**D**	**D**	**D**							**D**
Blue sucker														**C**
Highfin carpsucker														**C**
Northern hogsucker	**D**	**D**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Bigmouth buffalo														**C**

Smallmouth buffalo	**D**													**C**
Black buffalo														**C**
Quillback	**B**					**D**								**C**
Black redhorse	**D**	**D**	**C**	**C**	**D**	**D**	**D**	**D**	**D**	**D**				**D**
Golden redhorse	**D**	**D**	**A**		**D**	**D**	**D**	**D**	**C**	**D**				**D**
Shorthead redhorse		**B**			**C**									**C**
Silver redhorse					**D**									**C**
River redhorse														**C**
Black bullhead	**A**			**C**	**C**		**D**							**C**
Yellow bullhead	**D**	**C**	**C**	**C**	**D**	**C**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
Channel catfish					**D**					**A**				**C**
Flathead catfish														**C**
Blue catfish														**C**
Freckled madtom					**A**									

Slender madtom	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Stonecat					**D**									
Northern studfish	**D**	**D**		**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Blackspotted topminnow	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**A**		**D**
Plains topminnow	**A**	**C**	**D**	**D**	**D**			**B**		**D**	**D**	**D**		**D**
Western mosquitofish		**D**			**D**	**D**	**D**							**D**
Brook silverside	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**A**		**D**
Mottled sculpin	**D**				**D**	**D**		**D**						**D**
Banded sculpin						**D**				**C**	**D**	**A**		
Ozark sculpin					**D**						**D**	**D**		**D**
White bass					**D**									**C**
Rock bass		**B**	**C**	**C**										**D**
River carpsucker	**B**									**A**				**C**
Green sunfish	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Warmouth		**D**												

Orangespotted sunfish		**A**			**C**		**A**			**B**				**A**
Bluegill	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Longear sunfish	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**		**D**
Smallmouth bass	**D**	**D**	**D**	**D**	**D**	**D**	**A**	**D**	**B**	**D**	**D**	**D**		**D**
Spotted bass	**C**	**D**		**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Largemouth bass	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**C**	**D**		**D**
White crappie					**D**		**D**							**C**
Black crappie	**B**													**D**
Greenside darter	**D**	**D**	**C**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**A**		**D**
Rainbow darter	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Fantail darter		**D**		**D**		**D**	**D**	**D**	**D**	**D**		**D**		**D**
Least darter								**B**		**D**		**A**		
Niangua darter		**D**			**D**									
Johnny darter	**D**	**A**	**A**		**D**									**C**
Stippled darter	**C**	**C**	**C**	**D**		**D**				**D**	**D**	**A**		**D**

Orangethroat darter		**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**		**D**
Banded darter		**D**			**D**	**D**				**A**				**C**
Missouri saddled darter	**C**	**D**			**D**	**D**								**C**
Slenderhead darter					**D**									**D**
Gilt darter														**C**
Logperch		**D**			**D**	**D**	**D**	**D**	**C**	**D**		**D**		**D**
Northern pike														**C**
Walleye														**C**
Sauger	**B**													**C**
Freshwater drum	**B**				**C**				**D**	**D**				**D**

Time period collected: A = 1931-1946, B = 1947-1973, C = 1974-1990, D = 1991-2001

[1]The most recent collection period for Lower Osage R. was B (1947-1973).

[2]The most recent collection period for Upper LOZ Hills was C (1974-1990).